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A NUMERICAL MODEL ANALYSIS OF MISSISSIPPI RIVER PASSES NAVIGATION CHANNEL IMPROVEMENTS

Report 2

45-FOOT CHANNEL TESTS AND FLOW DIVERSION SCHEMES

by

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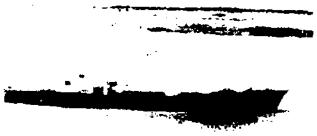

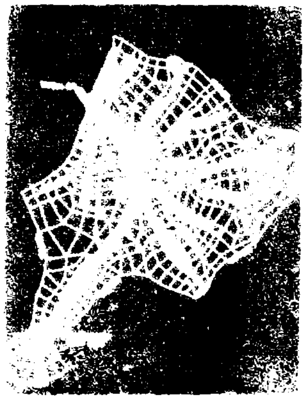

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The proposed deepening of the Southwest Pass of the Mississippi River to 45 feet is analyzed for its impacts on flow distributions and sedimentation changes. Flow redistributions and shoaling caused by bank losses in Southwest Passes and the forced suppression of flow into South Pass were analyzed. Results from two-dimensional numerical hydrodynamic and sediment transport models for a variety of plans and flow conditions is presented. The US Army Corps of Engineers TABS-2 modeling system is used. The constructed models cover the entire Mississippi River Delta downstream of Venice, Louisiana.

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Preface

The study described herein was conducted during 1985-1987 for the US Army Engineer District, New Orleans, by personnel of the Hydraulics Laboratory (HL) of the US Army Engineer Waterways Experiment Station (WES) under the general supervision of Messrs. H. B. Simmons and F. A. Herrmann, Jr., former and present Chiefs, respectively, of HL, and R. A. Sager and W. H. McAnally, former and present Chiefs, Estuaries Division (ED). The study was performed and this report written by Messrs. D. R. Richards and M. J. Trawle, ED. It is the second in a series of reports listed below.

COL Dwayne G. Lee, EN, is the Commander and Director of WES. Dr. Robert W. Whalin is the Technical Director.

Reports in this series:

Report 1: 55-Foot Channel Tests

Report 2: 45-Foot Channel Tests and Flow Diversion Schemes

Report 3: Bank Breaching Without Supplement 2

Report 4: Two-Dimensional Hydrodynamic and Sediment Transport Verification

Report 5: Three-Dimensional Numerical Model Results

Contents

Conversion Factors, Non-SI to SI (Metric) Units of Measurement

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
cubic feet	0.02831685	cubic metres
cubic yards	0.7645549	cubic metres
feet	0.3048	metres
miles (US statute)	1.609347	kilometres

A NUMERICAL MODEL ANALYSIS OF MISSISSIPPI RIVER PASSES NAVIGATION CHANNEL IMPROVEMENTS

45-FOOT CHANNEL TESTS AND FLOW DIVERSION SCHEMES

1. The purpose of this report is to provide in summary form the results from numerical model studies to date. It is the second in a series of reports written for this purpose. All of the project conditions reported on in this report involve analyses using the two-dimensional (2D) hydrodynamic and sediment transport models. They were not requested in the original scope of work, but it was agreed that these 2D analyses would be performed while code modifications were being made to the three-dimensional hydrodynamic model.

2. Shortly after the first draft report dated 30 June 1986 was reviewed by the US Army Engineer District, New Orleans (LMN), a variety of decisions were made by LMN that necessitated testing several new project conditions. The new conditions tested are summarized as follows:

- a. Higher flow retention Supplement 2 (SUPP2)
- b. 45-ft project depth, existing width (P145)
- c. Future condition without Supplement 2 (BANK)
- d. Reduced flow in South Pass (BASERED, SUPP2RED, P145RED)
- e. 460,000-cfs flow Base Condition

Results from each of these conditions are discussed in the following paragraphs.

Hydrodynamic Results

Higher flow retention Supplement 2 (SUPP2)

3. The original Supplement 2 modeling described in Report 1 of this series indicated that approximately 33 to 46 percent of the flow entering Southwest Pass would leak out before reaching the jetties. Discussions with LMN indicated that a reduced loss rate condition was needed. The original schematization of the Southwest Pass overbanks involved setting the overbank elevations to 0.5 ft below the 640,000-cfs free surface in a longitudinally stepped fashion. For the higher flow retention condition, the overbanks were raised in a longitudinally continuous fashion to 0.5 ft below the 640,000-cfs

free surface between Venice and Head of Passes and 0.2 ft between Head of Passes and the jetties. Results from this adjustment provided the desired loss rates of 15 to 38 percent of the entering flow. Table 1 summarizes the results (SUPP2).

4. Given that LMN will do whatever is necessary to reduce leakage through the numerous outlets along Southwest Pass, this latest schematization of Supplement 2 is considered to be final. The previous version should be ignored unless it is of interest to investigate a higher loss rate.

45-ft project depth,
existing width (P145)

5. Soon after the State of Louisiana and the Federal Government agreed on a formula for funding the 45-ft project, it was modeled for the existing width. It was agreed by LMN that a complete set of tests for the different channel widths would not be necessary for the 45-ft channel based on the negligible differences between the plans noticed in the 55-ft tests. Table 1 summarizes the hydrodynamic results for the existing width, 45-ft condition (P145).

6. There were negligible hydrodynamic differences between the existing 40-ft channel with Supplement 2 and the 45-ft channel with existing widths and Supplement 2 works in place. It is important to note, however, that the existing condition modeled has nearly a 45-ft channel based on overdepth dredging or natural causes. The point is that it would be erroneous to suggest that a net increase in depth of 5 ft with Supplement 2 works causes negligible flow redistributions. Without Supplement 2 the flow redistributions would be more noticeable in the deepened 45-ft condition.

Future condition
without Supplement 2 (BANK)

7. After the first submittal of results to LMN on 30 June 1986, LMN expressed an interest in modeling the effects of not building Supplement 2 on the existing (BASE) condition. It was decided that subsidence along with a general erosion of the overbanks could result in a 0.5-ft lowering of the overbanks. This condition (BANK) was modeled for the three flows and is compared to the BASE condition in Table 2.

8. Since significant portions of the currently dry overbanks would be awash with a 0.5-ft loss, roughness coefficients in the overbanks were reduced. The hydrodynamic results clearly indicate that this is not a desirable

condition. However, this general degradation of the overbanks may not be the worst case scenario for not constructing Supplement 2. A sizeable break through the overbanks could be more serious. Report 3 in this series investigates the results of such a break.

Reduced flow in South Pass
(BASERED, SUPP2RED, AND P145RED)

9. One of many scenarios envisioned by LMN to reduce shoaling in Southwest Pass was the construction of structures in South Pass to effectively divert flow from South Pass into Southwest Pass. Such a condition was schematically modeled by increasing the overall roughness in South Pass in the Base, Supplement 2, and 45-ft channel conditions (BASERED, SUPP2RED, and P145RED). The composite roughness throughout South Pass was increased from $n = 0.020$ to $n = 0.030$ in these conditions which would reflect a substantial number of training dikes. The purpose of the exercise was to determine what portion of the flow diverted away from South Pass would enter Southwest Pass. Table 3 summarizes the results. In short, approximately 3 percent of the Venice flow was diverted away from South Pass with a roughly 1 percent of the Venice flow increase in both Southwest Pass and Pass a Loutre. As discussed previously with LMN, South Pass flow suppression schemes tend to divert flow equally between Southwest Pass and Pass a Loutre. Suppressing flows in Pass a Loutre would probably provide more efficient diversions to Southwest Pass.

460,000-cfs flow base condition

10. A recent comment by LMN indicated that 460,000 cfs is a more typical yearly high discharge at Venice than 640,000 cfs. A 460,000-cfs discharge was run in the base condition to extend the range of flows tested. The results for all four tests flows are given in Table 4.

Sedimentation Results

11. Because of the almost continuous dredging activity that typically occurs along Southwest Pass during periods of high river stages, it is difficult to determine representative shoaling rates for high stage conditions. The approach used in this study to establish high-stage shoaling rates was to evaluate relatively short periods of time in 1982, 1983, and 1984. During

these selected time periods, the river stage was high and dredging activity was minimal.

12. Model verification was based on comparison of observed prototype shoaling rates along Southwest Pass during five relatively short periods of time (2 weeks to 1 month) in which the Carrollton stage ranged between 10 and 16 ft and dredging activity along Southwest Pass was nil. Using hydrographic surveys, prototype shoaling rates were calculated during December 1982, January 1983 (Mile 10-20 BHP only), December 1983 (Mile 6-20 BHP only), April 1984 (Mile 0-6 BHP only), and November 1984. The model was adjusted until shoaling along Southwest Pass for the range of flows tested fell within the band provided by the observed shoaling rates. Overall, the 2D sediment transport model behavior agreed well with the observed shoaling patterns. Results from the verification effort are included in Report 4 in this series.

13. The numerical sediment transport simulations were made using steady-state currents with a median grain size of 0.15 mm. Except for the BASE condition with the 460,000-cfs flow the sediment transport simulations were conducted for each of the conditions modeled hydrodynamically. Suspended sediment concentrations at the Head of Passes were approximately 150 ppm for the 640,000-cfs tests, 300 ppm for the 900,000-cfs tests, and 500 ppm for the 1,300,000-cfs tests.

14. Sediment transport predictions for each of the modeled conditions are given in Tables 5-8 expressed in cubic yards per month. Reductions or increases in shoaling rates are expressed in percentages of that observed in the existing (BASE) condition of 640,000 cfs, 900,000 cfs, and 1,300,000 cfs at Venice. There were changes in Supplement 2 (SUPP2) shoaling rates of -33, -21, and -9 percent, respectively, over the BASE condition (Table 5). For the 45-ft channel with plan 1 channels widths (P145), there were changes in shoaling rates for the 640,000-cfs, 900,000-cfs, and 1,300,000-cfs conditions of -26, -17, and +4 percent, respectively, over the BASE condition (Table 6). For the future without Supplement 2 (BANK) tests, there were changes in shoaling rates for the 640,000-cfs, 900,000-cfs, and 1,300,000-cfs conditions of +7, +15, and +55 percent, respectively, of the BASE condition (Table 7).

15. The reduced South Pass flow tests were conducted for the 640,000-cfs flow only. For the base condition the reduced South Pass (BASERED) tests resulted in a slight reduction in the shoaling rate along SWP of only 3 percent (Table 8). For both the Supplement 2 (SUPP2RED) and 45-ft channel with

Plan 1 widths (P145RED) condition tests, the reduced South Pass flow resulted in no change in shoaling along Southwest Pass (Table 8).

Summary

16. Based on the 2D sediment transport model for the flows tested, the following observations were made:

- a. The higher retention Supplement 2 works (SUPP2) will cause a reduction in shoaling along Southwest Pass of 9 to 33 percent. However the material transported through Southwest Pass with Supplement 2 still provides an entrance channel shoaling problem.
- b. The 45-ft channel with Plan 1 width (P145) will cause a change in shoaling along Southwest Pass ranging from -26 to +4 percent.
- c. The future without Supplement 2 condition (BANK) will cause an increase in shoaling ranging from 7 to 55 percent.
- d. The reduced South Pass tests (BASERED, SUPP2RED, and P145RED) did not achieve any significant reduction in Southwest Pass shoaling for the 640,000-cfs flow.

Table 1

Flow Distribution, Stages, and Velocities for

BASE, SUPP2 and P145 Condition

% of Venice Flow	640,000 cfs*			900,000 cfs*			1,300,000 cfs*		
	Base	SUPP2	P145	Base	SUPP2	P145	Base	SUPP2	P145
B. Collette	3	6	6	3	6	6	3	5	5
Grand/Tiger	4	9	9	4	8	8	4	6	6
Cubits Gap	6	9	9	6	8	8	6	8	8
SWP (& DS)**	32(15)	26(22)	26(22)	30(14)	26(19)	26(20)	29(13)	26(16)	26(17)
SP (& DS)**	17(2)	18(2)	18(2)	17(2)	18(2)	18(2)	17(2)	17(2)	17(2)
PAL	24	32	32	22	28	28	21	25	25
Channel†	86	100	100	82	94	94	80	87	87
Overbank†	14	0	0	18	6	6	20	13	13
Stage, ft NGVD††									
Venice	2.7	3.5	3.5	3.7	4.5	4.5	5.0	5.7	5.7
Cubits Gap	2.2	2.9	2.9	3.0	3.7	3.7	4.1	4.8	4.7
Head of Passes	2.0	2.7	2.7	2.7	3.4	3.4	3.6	4.3	4.3
Upper Southwest Pass	0.6	0.9	0.9	0.8	1.2	1.2	1.1	1.5	1.5
SWP Jetties	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Velocities, fps††									
Venice	4.5	4.5	4.5	6.4	6.3	6.3	8.7	8.7	8.6
Cubits Gap	3.0	2.9	2.9	4.0	3.9	3.9	5.2	5.1	5.2
Head of Passes	3.0	2.8	2.7	4.0	3.8	3.7	5.3	5.1	5.0
Upper Southwest Pass	1.5	2.2	2.1	2.1	2.7	2.7	2.9	3.4	3.4
SWP Jetties	1.0	1.6	1.6	1.4	2.0	2.0	1.9	2.4	2.5

* Discharge at Venice, LA.
** Downstream at entrance.
† Above Head of Passes.
†† Typical midstream.

Table 2

Flow Distribution, Stages, and Velocities for BASE and BANK Condition

	640,000 cfs*		900,000 cfs*		1,300,000 cfs*	
% of Venice Flow	BASE	BANK	BASE	BANK	BASE	BANK
B. Collette	3	2	3	2	3	2
Grand/Tiger	4	3	4	3	4	3
Cubits Gap	6	5	6	5	6	5
SWP (& DS)**	32 (15)	36 (12)	31 (14)	33 (12)	29 (13)	30 (11)
SP (& DS)**	17 (2)	16 (2)	17 (2)	16 (1)	17 (1)	17 (1)
PAL	24	21	22	20	20	19
Channel†	86	83	83	79	79	76
Overbank†	14	17	17	21	21	24
Stage, ft NGVD††						
Venice	2.7	2.4	3.7	3.4	5.0	4.6
Cubits Gap	2.2	1.9	3.0	2.8	4.1	3.8
Head of Passes	2.0	1.7	2.7	2.4	3.6	3.3
Upper Southwest Pass	0.6	0.4	0.8	0.6	1.1	0.9
SWP Jetties	0.0	0.0	0.0	0.0	0.0	0.0
Velocities, fps††						
Venice	4.5	4.6	6.4	6.4	8.7	8.7
Cubits Gap	3.0	3.0	4.0	4.0	5.2	5.1
Head of Passes	3.0	3.1	4.0	4.1	5.3	5.4
Upper Southwest Pass	1.5	1.4	2.1	2.0	2.9	2.8
SWP Jetties	1.0	0.7	1.4	1.1	1.9	1.5

* Discharge at Venice, LA.
** Downstream at entrance.
† Above Head of Passes.
†† Typical midstream.

Table 3

Flow Distribution, Stages, and Velocities for Reduced South Pass Flows in BASE, SUPP2, and P145, 640,000-cfs Condition*

% of Venice Flow	BASE	BASERED	Δ	SUPP2	SUPP2RED	Δ	P145	P145RED	Δ
B. Collette	3	3		6	6		6	6	
Grand/Tiger	4	4		9	9		9	9	
Cubits Gap	6	6		9	9		9	9	
SWP (& DS)**	32(15)	33(15)	+1	26(22)	27(22)	+1	26(22)	27(22)	+1
SP (& DS)**	17(2)	14(1)	-3	18(2)	15(1)	-3	18(2)	15(1)	-3
PAL	24	25	+1	32	33	+1	32	33	+1
Channel†	86	85		100	99		100	99	
Overbank†	14	15		0	1		0	1	
Stage, ft NGVD††									
Venice	2.7	2.7		3.5	3.5		3.5	3.5	
Cubits Gap	2.2	2.2		2.9	3.0		2.9	2.9	
Head of Passes	2.0	2.0		2.7	2.8		2.7	2.8	
Upper Southwest Pass	0.6	0.6		0.9	0.9		0.9	1.0	
SWP Jetties	0.0	0.0		0.0	0.0		0.0	0.0	
Velocities, fps††									
Venice	4.5	4.5		4.5	4.5		4.5	4.5	
Cubits Gap	3.0	3.0		2.9	2.9		2.9	2.9	
Head of Passes	3.0	3.0		2.8	2.8		2.7	2.7	
Upper Southwest Pass	1.5	1.6		2.2	2.2		2.1	2.2	
SWP Jetties	1.0	1.0		1.6	1.6		1.6	1.7	

* Discharge at Venice, LA.
** Downstream at entrance.
† Above Head of Passes.
†† Typical midstream.

Table 4

Flow Distribution, Stages, and Velocities for BASE Condition, Four Flows

% of Venice Flow	460,000 cfs*	640,000 cfs*	900,000 cfs*	1,300,000 cfs*
B. Collette	3	3	3	3
Grand/Tiger	4	4	4	4
Cubits Gap	6	6	6	6
SWP (& DS)**	33 (15)	32 (15)	30 (14)	29 (13)
SP (& DS)**	17 (2)	17 (2)	17 (2)	17 (2)
PAL	25	24	22	21
Channel†	88	86	82	80
Overbank†	12	14	18	20
Stage, ft NGVD††				
Venice	1.8	2.7	3.7	5.0
Cubits Gap	1.5	2.2	3.0	4.1
Head of Passes	1.3	2.0	2.7	3.6
Upper Southwest Pass	0.4	0.6	0.8	1.1
SWP Jetties	0.0	0.0	0.0	0.0
Velocities, fps††				
Venice	3.1	4.5	6.4	8.7
Cubits Gap	2.2	3.0	4.0	5.2
Head of Passes	2.1	3.0	4.0	5.3
Upper Southwest Pass	1.1	1.5	2.1	2.9
SWP Jetties	0.7	1.0	1.4	1.9

* Discharge at Venice, LA.
** Downstream at entrance.
† Above Head of Passes.
†† Typical midstream.

Table 5

Reduction in Shoaling Along Southwest Pass (Mile 0-20 BHP) Resulting from Supplement 2 Works (SUPP2)

Discharge (1,000 cfs)	BASE Shoaling (10^6 cu yd/month)	SUPP2 Shoaling (10^6 cu yd/month)	Reduction (percent)
640	0.92	0.62	-33
900	1.36	1.07	-21
1300	2.55	2.32	- 9

Table 6

Changes in Shoaling Along Southwest Pass (Mile 0-20 BHP) Resulting from Supplement 2 and 45-Foot Channel (P145)

Discharge (1,000 cfs)	BASE Shoaling (10^6 cu yd/month)	P145 Shoaling (10^6 cu yd/month)	Change (percent)
640	0.92	0.68	-26
900	1.36	1.13	-17
1300	2.55	2.65	+ 4

Table 7

Increase in Shoaling Along Southwest Pass (Mile 0-20 BHP) Resulting from Future Condition Without Supplement 2 (BANK)

Discharge (1,000 cfs)	BASE Shoaling (10^6 cu yd/month)	BANK Shoaling (10^6 cu yd/month)	Increase (percent)
640	0.92	0.98	+ 7
900	1.36	1.56	+15
1300	2.55	3.95	+55

Table 8

Changes in Shoaling Along Southwest Pass (Mile 0-20 BHP)
Resulting from Reduced Flow in South Pass

Base Condition

Discharge (1,000 cfs)	BASE Shoaling (10^6 cu yd/month)	BASERED Shoaling (10^6 cu yd/month)	Change (Percent)
640	0.92	0.89	-3

Supplement 2 Condition

Discharge (1,000 cfs)	SUPP2 Shoaling (10^6 cu yd/month)	SUPP2RED Shoaling (10^6 cu yd/month)	Change (Percent)
640	0.62	0.62	N.C.

45-ft Channel Condition

Discharge (1,000 cfs)	P145 Shoaling (10^6 cu yd/month)	P145RED Shoaling (10^6 cu yd/month)	Change (Percent)
640	0.68	0.68	N.C.